2016 Soil Mechanics II and Exercises Final Exam

2016/7/27 (Wed) 10:00-12:00 Kyotsu 4 Lecture room

Attention:

- The exam consists of five questions for which you are provided with five answer sheets. Write down your name and ID number on every answer sheet. Use one answer sheet per question and answer them in sequence, starting from [Question 1]. If the front page of an answer sheet is insufficient to complete your answer, use the back page of the same answer sheet after clearly indicating your intent.
- Scores of all questions are weighted evenly.
- In addition to personal writing instruments, non-programmable calculators are permitted. However, programmable calculators and calculator functions of mobile phones are prohibited. Any attempts at cheating on the exam will result in failed credit of the course and serious penalties.
- Wherever necessary, specify the units in your answers.

[Question 1] Answer the following questions:

(1) Consider the homogeneous and uniform 10 m thick clay layer lying above the non-artesian gravel layer (fully drained layer) shown in Figure 1. Herein, the saturated unit weight of the soil is γ_{sat}, the unit weight of water is γ_w, the coefficient of consolidation is c_v, the compression index is Cc, and the initial void ratio of the soil is e_0. Let the clay layer carry a uniform load Δp = 100 kN/m^2 over a sufficiently large area compared to its thickness. Calculate the time required for the clay layer to reach an average degree of consolidation U = 90%, and the amount of total subsidence (final settlement). Upon calculation of the settlement, the groundwater level is assumed to be at the surface of the clay layer and the representative value of the stress in the ground can be taken at the center of the clay layer (i.e., at a depth of 5 m). The time factor corresponding to U = 90% is T_v = 0.848.

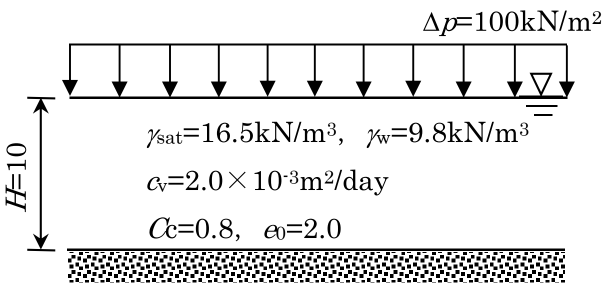

Figure 1

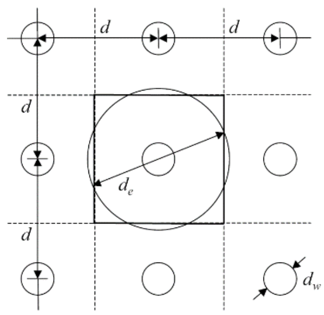

Figure 2

(2) In order to reduce the time taken for the consolidation process calculated in (1), sand drains are driven into the clay layer following the layout shown in Figure 2 (diameter of sand drains d_w = 0.4 m, length = 10 m into the clay layer, square array at a pitch d = 2.13 m). After their installation, the clay layer is subjected to a uniform load Δp = 100 kN/m^2 over a sufficiently large area compared to its thickness, exactly the same way as indicated in (1). In this case, calculate the time required for the improved clay layer to reach an average degree of consolidation U = 90%, in accordance to the following procedures. Assume that the flow of water in the ground with sand drains takes place only in the horizontal direction, toward said sand drains.

1) Take the side length of a square surrounding the center of an installed column of sand drain equal to the pitch, and then calculate the effective diameter d_e of a circle whose cross-sectional area equals the area of the square in which water is collected.

2) Obtain the time factor T_h for horizontal drainage that corresponds to an average degree of consolidation U = 90% from the diagram representing the theoretical solution of Barron (Figure 3).

3) Find the time required for the clay layer with sand drains to reach an average degree of consolidation U = 90%. In this case, it is assumed that the coefficient of consolidation of the clay layer is not changed by the installation of the sand drains, and anisotropic permeability is not accounted for (coefficient of consolidation for horizontal drainage $c_h = c_v$).

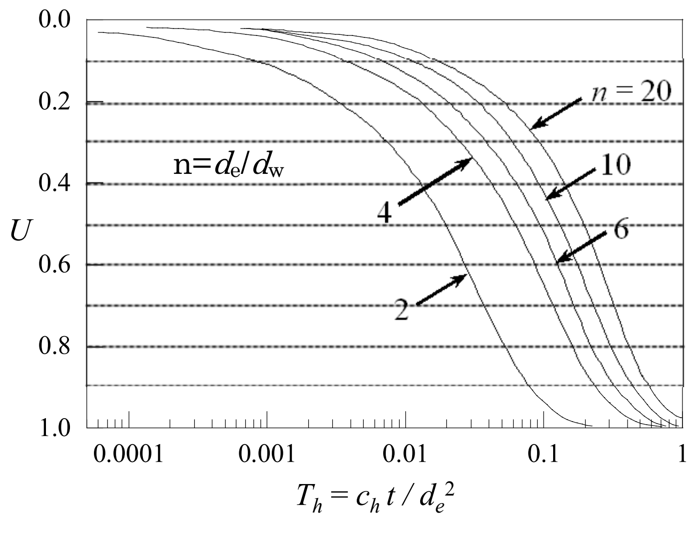

Figure 3

[Question 2] Answer the following questions:

(1) Using a figure (or figures) representing the τ−σ plane, graphically outline the main features of the 3 types of failure criteria (Coulomb's, Mohr's, and Mohr-Coulomb's failure criterion) explaining, in general terms, the characteristics of each of them.

(2) Use figures to explain the following terms:

1) Ratio of sensitivity

2) Undrained shear strength

3) Dilatancy

[Question 3]

As shown in Figure 4, a rigid retaining wall, 4 m high, with a fully smooth vertical back face, retains a flat cohesionless backfill with a uniform surcharge of 10 kN/m^2. During dry season, the groundwater table drops far below the base of the wall and the unit weight of the backfill equals its wet unit weight γ_t = 15.5 kN/m^3. During rainy season, however, the drain holes become clogged due to a poor design, and the groundwater table rises to the backfill surface and develops hydrostatic pressure behind the retaining wall, while the unit weight of the backfill equals its saturated unit weight γ_{sat} = 19.0 kN/m^3.

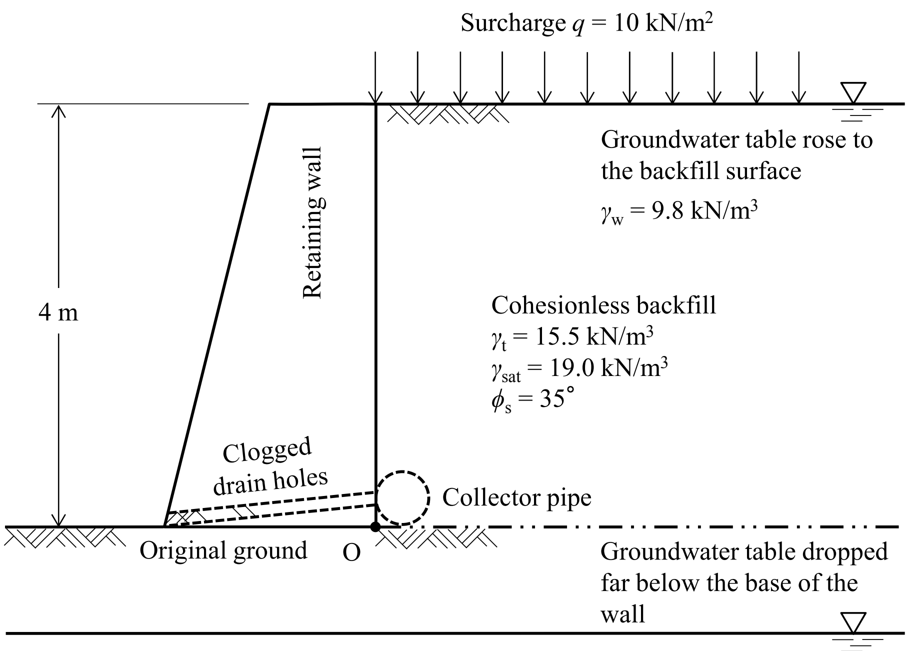

Figure 4

Herein, the unit weight of water is γ_w = 9.8 kN/m^3 and the friction angle of the backfill is ϕ_s = 35°. According to Rankine active earth pressure, answer the following questions.

(1) Calculate the total resultant force per unit length of the wall and the corresponding overturning moment per unit length of the wall about a point O, during dry season.

(2) Calculate the total resultant force per unit length of the wall and the corresponding overturning moment per unit length of the wall about a point O, during rainy season.

(3) Discuss the importance of drainage system in retaining walls from the view point of their stability.

[Question 4] Answer the following questions:

(1) Explain when a foundation is defined as shallow or deep, based on its width, B, and depth, D_f
(2) Use a graphic to describe the failure mechanism of a shallow strip foundation after Terzaghi's general shear failure theory, and include a brief explanation of it
(3) Express Terzaghi's formula to calculate the ultimate bearing capacity, q_{d}, of a shallow strip foundation, and briefly explain each element
(4) Explain how to obtain the allowable bearing capacity, q_{a}, of a shallow strip foundation built at a depth D_{f}, after applying a factor of safety, F, to its ultimate bearing capacity, q_{d}

[Question 5] Answer the following questions:

(1) Determine the factor of safety, F, of an infinite slope against sliding, along the slip plane located at a depth H. The slope is inclined at an angle β, the cohesion is c, the internal friction angle is ϕ, and the unit weight of the soil mass is γ. Herein, it is assumed that the level of the groundwater table is sufficiently deep.

(2) Find the critical depth H_c at which the plane failure of the infinite slope mentioned in (1) occurs.

(3) By paying attention to changes in the factor of safety against sliding, explain why landslides are likely to occur when it rains

(4) Explain the mechanism of soil liquefaction at the time of earthquake in the context of the dilatancy of soils.